

WHAT IS CLAIMED IS:

1. A reproducing apparatus comprising:
 - first means for reproducing a signal representative of digital
5 information from a recording medium;
 - second means for sampling the signal reproduced by the first means
in response to a clock signal to generate a sampling-resultant signal;
 - third means for subjecting the sampling-resultant signal to a
re-sampling process and an interpolation process responsive to timing
10 information to generate a re-sampling-resultant signal;
 - fourth means for deciding whether the re-sampling-resultant signal
is in a continuous-wave interval where an inversion period of the
re-sampling-resultant signal remains constant or in a random-wave
interval where the inversion period of the re-sampling-resultant signal
15 varies at random;
 - fifth means for extracting a first value of the re-sampling-resultant
signal at a time point corresponding to every zero-cross timing, for
controlling a polarity of the extracted first value in response to whether the
re-sampling-resultant signal is rising or falling in value to generate a
20 polarity-control-resultant value, and for generating a first phase error in
response to the polarity-control-resultant value;
 - sixth means for repetitively extracting a second value of the
re-sampling-resultant signal at a constant period corresponding to a
normal inversion period occurring during the continuous-wave interval, for
25 alternately changing a polarity of the extracted second value between
positive and negative to generate a polarity-change-resultant value, and for
generating a second phase error in response to the
polarity-change-resultant value;

seventh means for selecting the first phase error generated by the fifth means when the fourth means decides that the re-sampling-resultant signal is in a random-wave interval, and for selecting the second phase error generated by the sixth means when the fourth means decides that the re-sampling-resultant signal is in a continuous-wave interval;

a loop filter for integrating the phase error selected by the seventh means to generate a phase-error integration result; and

eighth means for generating the timing information in response to the phase-error integration result generated by the loop filter.

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2. A reproducing apparatus comprising:

first means for reproducing a signal representative of digital information from a recording medium;

second means for sampling the signal reproduced by the first means in response to a clock signal to generate a sampling-resultant signal;

third means for deciding whether the sampling-resultant signal is in a continuous-wave interval where an inversion period of the sampling-resultant signal remains constant or in a random-wave interval where the inversion period of the sampling-resultant signal varies at random;

fourth means for extracting a first value of the sampling-resultant signal at a time point corresponding to every zero-cross timing, for controlling a polarity of the extracted first value in response to whether the sampling-resultant signal is rising or falling in value to generate a polarity-control-resultant value, and for generating a first phase error in response to the polarity-control-resultant value;

fifth means for repetitively extracting a second value of the sampling-resultant signal at a constant period corresponding to a normal

inversion period occurring during the continuous-wave interval, for alternately changing a polarity of the extracted second value between positive and negative to generate a polarity-change-resultant value, and for generating a second phase error in response to the

5 polarity-change-resultant value;

sixth means for selecting the first phase error generated by the fourth means when the third means decides that the sampling-resultant signal is in a random-wave interval, and for selecting the second phase error generated by the fifth means when the third means decides that the
10 sampling-resultant signal is in a continuous-wave interval; and

seventh means for generating the clock signal in response to the phase error selected by the sixth means.

3. A reproducing apparatus as recited in claim 1, wherein the fourth
15 means comprises:

means for deciding whether or not a latest inversion period Y of the re-sampling-resultant signal satisfies one of relations as follows:

$$X - 1 \leq Y \leq X + 1$$

$$X - 2 \leq Y \leq X$$

20 $X \leq Y \leq X + 2$

where X denotes the normal inversion period occurring in the continuous-wave interval;

means for deciding whether or not the latest inversion period Y consecutively satisfies one of the relations a prescribed number of times;

25 and

means for deciding that the re-sampling-resultant signal is in a continuous-wave interval when the latest inversion period Y consecutively satisfies one of the relations the prescribed number of times.

4. A reproducing apparatus as recited in claim 1, wherein the fourth means comprises:

means for detecting a latest period Z for which the
5 re-sampling-resultant signal either rises or falls;
means for deciding whether or not the latest period Z satisfies one of relations as follows:

$$2X - 1 \leq Z \leq 2X + 1$$

$$2X - 2 \leq Z \leq 2X$$

10 $2X \leq Z \leq 2X + 2$

where X denotes the normal inversion period occurring in the continuous-wave interval;

means for deciding whether or not the latest period Z consecutively satisfies one of the relations a prescribed number of times; and

15 means for deciding that the re-sampling-resultant signal is in a continuous-wave interval when the latest period Z consecutively satisfies one of the relations the prescribed number of times.

5. A reproducing apparatus as recited in claim 1, wherein the fourth
20 means comprises:

means for deciding whether or not a latest inversion period of the re-sampling-resultant signal exceeds a preset period; and

means for controlling the seventh means to select the first phase error when it is decided that the latest inversion period of the
25 re-sampling-resultant signal exceeds the preset period.

6. A reproducing apparatus comprising:

first means for reproducing a signal representative of digital

information from a recording medium;

second means for sampling the signal reproduced by the first means in response to a clock signal to generate a sampling-resultant signal;

third means for deciding whether the sampling-resultant signal is in
5 a specified-pattern repetition interval where an inversion period of the sampling-resultant signal changes in accordance with a repetition of a specified pattern or in a random-wave interval where the inversion period of the sampling-resultant signal varies at random;

fourth means for extracting a first value of the sampling-resultant
10 signal at a time point corresponding to every zero-cross timing, for controlling a polarity of the extracted first value in response to whether the sampling-resultant signal is rising or falling in value to generate a first polarity-control-resultant value, and for generating a first phase error in response to the first polarity-control-resultant value;

15 fifth means for repetitively extracting a second value of the sampling-resultant signal at a period changing in accordance with the specified pattern, for controlling a polarity of the extracted second value in response to whether the extracted second value is in a value-rising time or a value-falling time to generate a second polarity-control-resultant value, and
20 for generating a second phase error in response to the second polarity-control-resultant value;

sixth means for selecting the first phase error generated by the fourth means when the third means decides that the sampling-resultant signal is in a random-wave interval, and for selecting the second phase
25 error generated by the fifth means when the third means decides that the sampling-resultant signal is in a specified-pattern repetition interval; and

seventh means for generating the clock signal in response to the phase error selected by the sixth means.

7. A reproducing apparatus comprising:

first means for reproducing a signal representative of digital information from a recording medium;

5 second means for sampling the signal reproduced by the first means in response to a clock signal to generate a sampling-resultant signal;

third means for subjecting the sampling-resultant signal to a re-sampling process and an interpolation process responsive to timing information to generate a re-sampling-resultant signal;

10 fourth means for deciding whether the re-sampling-resultant signal is in a specified-pattern repetition interval where an inversion period of the re-sampling-resultant signal changes in accordance with a repetition of a specified pattern or in a random-wave interval where the inversion period of the re-sampling-resultant signal varies at random;

15 fifth means for extracting a first value of the re-sampling-resultant signal at a time point corresponding to every zero-cross timing, for controlling a polarity of the extracted first value in response to whether the re-sampling-resultant signal is rising or falling in value to generate a first polarity-control-resultant value, and for generating a first phase error in
20 response to the first polarity-control-resultant value;

sixth means for repetitively extracting a second value of the re-sampling-resultant signal at a period changing in accordance with the specified pattern, for controlling a polarity of the extracted second value in response to whether the extracted second value is in a value-rising time or a
25 value-falling time to generate a second polarity-control-resultant value, and for generating a second phase error in response to the second polarity-control-resultant value;

seventh means for selecting the first phase error generated by the

fifth means when the fourth means decides that the re-sampling-resultant signal is in a random-wave interval, and for selecting the second phase error generated by the sixth means when the fourth means decides that the re-sampling-resultant signal is in a specified-pattern repetition interval;

5 a loop filter for integrating the phase error selected by the seventh means to generate a phase-error integration result; and

 eighth means for generating the timing information in response to the phase-error integration result generated by the loop filter.

10 8. A reproducing apparatus as recited in claim 6, wherein the third means comprises:

 means for deciding whether or not a latest inversion period $Y(i)$ of the sampling-resultant signal satisfies one of relations as follows:

$$Y(i-J) - 1 \leq Y(i) \leq Y(i-J) + 1$$

15 $Y(i-J) - 2 \leq Y(i) \leq Y(i-J)$

$$Y(i-J) \leq Y(i) \leq Y(i-J) + 2$$

where J denotes a number of inversion period elements composing the specified pattern;

 means for deciding whether or not the latest inversion period $Y(i)$
20 consecutively satisfies one of the relations a prescribed number of times;
and

 means for deciding that the sampling-resultant signal is in a specified-pattern repetition interval when the latest inversion period $Y(i)$ consecutively satisfies one of the relations the prescribed number of times.

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9. A reproducing apparatus as recited in claim 6, wherein the third means comprises:

 means for deciding whether or not a latest inversion period $Z(i+k)$ of

the sampling-resultant signal satisfies one of relations as follows:

$$X(k) - 1 \leq Z(i+k) \leq X(k) + 1$$

$$X(k) - 2 \leq Z(i+k) \leq X(k)$$

$$X(k) \leq Z(i+k) \leq X(k) + 2$$

5 where $X(k)$ denotes one among inversion period elements composing the specified pattern;

means for deciding whether or not the latest inversion period $Z(i+k)$ consecutively satisfies one of the relations a prescribed number of times; and

10 means for deciding that the sampling-resultant signal is in a specified-pattern repetition interval when the latest inversion period $Z(i+k)$ consecutively satisfies one of the relations the prescribed number of times.

10. A reproducing apparatus as recited in claim 6, wherein the third
15 means comprises:

means for deciding whether or not a latest inversion period $Y(i+1)$ and a second latest inversion period $Y(i)$ of the sampling-resultant signal satisfy one of relations as follows:

$$Y(i) \bullet 2 < Y(i+1)$$

20 $Y(i) > Y(i+1) \bullet 2;$

where the character " \bullet " denotes product; and

means for starting the decision about whether the sampling-resultant signal is in a specified-pattern repetition interval or a random-wave interval when it is decided that the latest inversion period
25 $Y(i+1)$ and the second latest inversion period $Y(i)$ satisfy one of the relations.

11. A reproducing apparatus as recited in claim 6, wherein the third means comprises:

means for measuring a time interval for which the
sampling-resultant signal remains in a specified-pattern repetition interval;
and

means for controlling the sixth means to select the first phase error
5 when the measured time interval reaches a predetermined time value.

12. A reproducing apparatus as recited in claim 6, wherein the specified
pattern includes a succession of inversion periods as $5T \bullet 5T \bullet 3T \bullet 3T \bullet 2T \bullet 2T$,
where T denotes a bit period of the digital information.

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13. A reproducing apparatus as recited in claim 1, wherein the third
means, the fifth means, the sixth means, the seventh means, the loop filter,
and the eighth means compose a feedback loop, and further comprising
means for changing a loop gain of the feedback loop in response to which of
15 the first phase error and the second phase error is selected by the seventh
means.

14. A reproducing apparatus as recited in claim 6, wherein the sixth
means comprises means for selecting only the second phase error which
20 corresponds to an inversion period longer than a prescribed period.

15. A reproducing apparatus as recited in claim 1, wherein the seventh
means comprises:

means for measuring a time interval for which the second phase
25 error remains selected; and

means for selecting the first phase error instead of the second phase
error when the measured time interval reaches a predetermined time value.

16. A computer program used for a reproducing apparatus comprising first means for reproducing a signal representative of digital information from a recording medium, second means for sampling the signal reproduced by the first means in response to a clock signal to generate a
5 sampling-resultant signal, and a computer, the computer program enabling the computer to operate as:

third means for deciding whether the sampling-resultant signal is in a continuous-wave interval where an inversion period of the sampling-resultant signal remains constant or in a random-wave interval
10 where the inversion period of the sampling-resultant signal varies at random;

fourth means for extracting a first value of the sampling-resultant signal at a time point corresponding to every zero-cross timing, for controlling a polarity of the extracted first value in response to whether the
15 sampling-resultant signal is rising or falling in value to generate a polarity-control-resultant value, and for generating a first phase error in response to the polarity-control-resultant value;

fifth means for repetitively extracting a second value of the sampling-resultant signal at a constant period corresponding to a normal
20 inversion period occurring during the continuous-wave interval, for alternately changing a polarity of the extracted second value between positive and negative to generate a polarity-change-resultant value, and for generating a second phase error in response to the polarity-change-resultant value;

25 sixth means for selecting the first phase error generated by the fourth means when the third means decides that the sampling-resultant signal is in a random-wave interval, and for selecting the second phase error generated by the fifth means when the third means decides that the

sampling-resultant signal is in a continuous-wave interval; and

seventh means for generating the clock signal in response to the phase error selected by the sixth means.

- 5 17. A computer program used for a reproducing apparatus comprising first means for reproducing a signal representative of digital information from a recording medium, second means for sampling the signal reproduced by the first means in response to a clock signal to generate a sampling-resultant signal, and a computer, the computer program enabling
10 the computer to operate as:

third means for deciding whether the sampling-resultant signal is in a specified-pattern repetition interval where an inversion period of the sampling-resultant signal changes in accordance with a repetition of a specified pattern or in a random-wave interval where the inversion period of
15 the sampling-resultant signal varies at random;

fourth means for extracting a first value of the sampling-resultant signal at a time point corresponding to every zero-cross timing, for controlling a polarity of the extracted first value in response to whether the sampling-resultant signal is rising or falling in value to generate a first
20 polarity-control-resultant value, and for generating a first phase error in response to the first polarity-control-resultant value;

fifth means for repetitively extracting a second value of the sampling-resultant signal at a period changing in accordance with the specified pattern, for controlling a polarity of the extracted second value in
25 response to whether the extracted second value is in a value-rising time or a value-falling time to generate a second polarity-control-resultant value, and for generating a second phase error in response to the second polarity-control-resultant value;

sixth means for selecting the first phase error generated by the fourth means when the third means decides that the sampling-resultant signal is in a random-wave interval, and for selecting the second phase error generated by the fifth means when the third means decides that the sampling-resultant signal is in a specified-pattern repetition interval; and
seventh means for generating the clock signal in response to the phase error selected by the sixth means.

18. A reproducing apparatus as recited in claim 1, further comprising:
ninth means for recovering the digital information from the re-sampling-resultant signal;
tenth means for deciding whether or not a sync signal regularly appears in the recovered digital information; and
eleventh means for forcing the seventh means to select the first phase error when the tenth means decides that a sync signal regularly appears in the recovered digital information.

19. A reproducing apparatus as recited in claim 6, further comprising:
eighth means for recovering the digital information from the sampling-resultant signal;
ninth means for deciding whether or not a sync signal regularly appears in the recovered digital information; and
tenth means for forcing the sixth means to select the first phase error when the ninth means decides that a sync signal regularly appears in the recovered digital information.